(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 June 2002 (13.06.2002)

PCT

(10) International Publication Number
WO 02/46205 A2

(51) International Patent Classification[7]: C07H 21/00

(21) International Application Number: PCT/GB01/05338

(22) International Filing Date: 3 December 2001 (03.12.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

0029610.3	5 December 2000 (05.12.2000)	GB
09/740,031	20 December 2000 (20.12.2000)	US

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 02/46205 A2

(54) Title: PROCESS FOR THE PREPARATION OF PHOSPHOROTHIONATE OLIGONUCLEOTIDES

(57) Abstract: A process for the synthesis of phosphorothioate oligonucleotides is provided which comprises assembling an aligonucleotide bound to to a solid support in the presence of acetonitrile; prior to cleaving the oligonucleotide from the solid support removing the acetonitrile; and cleaving the oligonucleotide from the solid support. The process is particularly suited to the large scale synthesis of nucleotides. The acetonitrile may be removed from the solid support by one or both to drying and by washing with solvents. Preferred washing solvents comprise trialkylamines.

PROCESS FOR THE PREPARATION OF PHOSPHOROTHIOATE OLIGONUCLEOTIDES

The present invention concerns a method for the synthesis of phosphorothioate oligonucleotides.

In the past 15 years or so, enormous progress has been made in the development of the synthesis of oligodeoxyribonucleotides (DNA sequences), oligoribonucleotides (RNA sequences) and their analogues 'Methods in Molecular Biology, Vol. 20, Protocol for Oligonucleotides and Analogs', Agrawal, S. Ed., Humana Press, Totowa, 1993. Much of the work has been carried out on a *micromolar* or even smaller scale, and automated solid phase synthesis involving monomeric phosphoramidite building blocks Beaucage, S. L.; Caruthers, M. H. *Tetrahedron Lett.*, 1981, 22, 1859-1862 has proved to be the most convenient approach. Indeed, high molecular weight DNA and relatively high molecular weight RNA sequences can now be prepared routinely with commercially available synthesisers. These synthetic oligonucleotides have met a number of crucial needs in biology and biotechnology.

Whereas milligram quantities have generally sufficed for molecular biological purposes, gram to greater than 100 gram quantities are required for clinical trials. Several oligonucleotide analogues that are potential antisense drugs are now in advanced clinical trials. If, as seems likely in the very near future, one of these sequences becomes approved, say, for the treatment of AIDS or a form of cancer, kilogram, multikilogram or even larger quantities of a specific sequence or sequences will be required.

Many of the oligonucleotides currently of interest in the phamaceutical industry are analogues of natural oligonucleotides which comprise phosphorothioated-internucleoside linkages. When phosphorothioate linkages are present, particularly when such linkages comprise a major proportion of the linkages, and especially when they comprise 100% of the internucleoside linkages, it is highly desirable that the concentration of impurity, non-phosphorothioated linkages in the final product is kept to a pharmacologically acceptable level.

A large number of protocols for the synthesis of oligonucleotides employ acetonitrile as a solvent for the reagents employed. Acetonitrile is attractive as a solvent because it is inert towards the reagents and oligonucleotide product, it has good solvation properties and is environmentally acceptable. Commonly, for large-scale syntheses, a high concentration of acetonitrile is present during the stage when the oligonucleotide product is cleaved from the solid support. Hitherto, this has been acceptable for large scale synthesis because of the perceived inert nature of acetonitrile. However, during the course of the studies resulting in the present invention, it has now been surprisingly found that higher purity oligonucleotides can be obtained by reducing the concentration of acetonitrile present during the cleavage stage.

According to one aspect of the present invention, there is provided a process for the large-scale synthesis of phosphorothioate oligonucleotides which comprises:

a) assembling an oligonucleotide bound to a solid support in the presence of acetonitrile; and

b) cleaving the oligonucleotide from the solid support;

characterised in that the concentration of acetonitrile is reduced to less than 10% by weight of the oligonucleotide plus solid support prior to the cleavage of the oligonucleotide from the solid support.

The phosphorothioate oligonucleotides can be assembled by known techniques for solid phase synthesis, for example using H-phosphonate or particularly phosphoramidite chemistry. For the phosphoramidite approach, commonly, the sequence employed is: deprotection of the nucleoside bound to solid support, preferably at the 5'-position; coupling of a, preferably 3'-, phosphoramidite nucleoside to form a supported oligonucleotide; sulphurisation of the supported oligonucleotide by reaction with a sulphurising agent to produce a supported phosphorothioate oligonucleotide; and capping of unreacted supported nucleoside with a capping reagent. This cycle is then repeated as often as is necessary to assemble the desired sequence of the oligonucleotide. When a mixed phosphate/phosphorothioate product is desired, the sulphurisation stage can be replaced with an oxidation step to produce a phosphate linkage at the desired location. On completion of the assembly, and prior to cleavage from the support, the supported oligonucleotide is commonly washed with acetonitrile in order to remove traces of unreacted reagents.

Acetonitrile can be removed by drying of the supported oligoncleotide, optionally under reduced pressure. The acetonitrile is commonly removed at ambient temperature, for example from 15 to 30°C, although elevated temperatures, such as from 30 to 80°C, for example from 40 to 60°C, may be employed.

The process according to the first aspect of the present invention is employed for large scale synthesis of oligonucleotides. Large scale synthesis of oligonucleotides is often regarded as being at or above a batch size of 10 mmol oligonucleotide, commonly at or above 15mmol, often at or above 25 mmol, for example greater than 50 mmol, and especially greater than 75 mmol of oligonucleotide. In many embodiments, the process of the present invention is employed for oligonucleotide synthesis at a scale in the range of from 100-500 mmol.

On completion of the assembly of the desired product, the product may be cleaved from the solid support. Cleavage methods employed are those known in the art for the given solid support. When the product is bound to the solid support via a cleavable linker, cleavage methods appropriate for the linker are employed, for example, contact with methylamine, aqueous methylamine solution, liquified ammonia, gaseous ammonia and particularly contact with concentrated aqueous ammonia solution.

Following cleavage, the product can be purified using techniques known in the art, such as one or more of ion-exchange chromatography, reverse phase chromatography, and precipitation from an appropriate solvent. Further processing of the product by for example ultrafiltration may also be employed.

Solid supports that are employed in the process according to the present invention are substantially insoluble in the solvent employed, and include those supports well known in the art for the solid phase synthesis of oligonucleotides. Examples include silica, controlled pore glass, polystyrene, copolymers comprising polystyrene such as polystyrene-poly(ethylene glycol) copolymers and polymers such as polyvinylacetate. Additionally, microporous or soft gel supports, especially poly(acrylamide) supports, such as those more commonly employed for the solid phase synthesis of peptides may be employed if desired. Preferred poly(acrylamide) supports are amine-functionalised supports, especially those derived from supports prepared by copolymerisation of acryloyl-sarcosine methyl ester, N,N-dimethylacrylamide and bis-acryloylethylenediamine, such as the commercially available (Polymer Laboratories) support sold under the catalogue name PL-DMA. The procedure for preparation of the supports has been described by Atherton, E.; Sheppard, R. C.; in *Solid Phase Synthesis: A Practical Approach,* Publ., IRL Press at Oxford University Press (1984). The functional group on such supports is a methyl ester and this is initially converted to a primary amine functionality by reaction with an alkyl diamine, such as ethylene diamine.

According to a second aspect of the present invention, there is provided a process for the synthesis of phosphorothioate oligonucleotides which comprises:

a) assembling an oligonucleotide bound to a solid support in the presence of acetonitrile;

b) prior to cleaving the oligonucleotide from the solid support, washing the oligonucleotide bound to a solid support with a washing regime employing one or more solvent washes; and

c) cleaving the oligonucleotide from the solid support

characterised in that the final wash of the washing regime employs a solvent other than acetonitrile or dioxane.

The washing regime employs one or more solvent washes. When the washing regime comprises a single wash, the solvent employed is free from acetonitrile and dioxane. When more than one solvent wash is employed, acetonitrile and dioxane may be employed in the wash stages other than the final wash. However, it is preferred that acetonitrile and dioxane are not employed in any stage of the washing regime.

Solvents which can be employed are preferably inert solvents which do not degrade the oligonucleotide under the conditions under which the solvent is employed. Examples of inert solvents that can be employed include inert organic solvents and inert aqueous solvents.

Preferably, the washing with solvent is effected such that the concentration of acetonitrile is reduced to less than 10% by weight of the oligonucleotide plus solid support.

Organic solvents which can be employed include aromatic hydrocarbons, for example toluene; aliphatic hydrocarbons, for example cyclohexane; haloalkanes, particularly dichloromethane; esters, particularly alkyl esters such as ethyl acetate and methyl or ethyl propionate; alcohols, particularly aliphatic alcohols such as C_{1-4} alkyl alcohols, for example methanol, ethanol or isopropanol; amides, such as dimethylformamide and N-methylpyrollidinone; basic, nucleophilic solvents such as pyridine or alkylamines, especially tri(alkyl), such as tri(C_{1-4}-alkyl)amines; polar ethers such as tetrahydrofuran; and sulphoxides, for example dimethylsulphoxide.

Aqueous solvents that can be employed include water, aqueous buffer solutions, mixtures of water and water miscible inert organic solvents, especially those solvents described above.

Solid supports that may be employed are those described with the respect to the first aspect of the present invention. In many embodiments, it may be preferred to employ an organic solvent when the support is hydrophobic, such as poly(styrene). In other embodiments, it may be preferred to employ an aqueous solvent when the support is hydrophilic, such as controlled pore glass or silica. In further embodiments, when the support is microporous, it may be preferred to employ a solvent which swells the support.

In certain preferred embodiments, the solvent employed serves to remove protecting groups from the oligonucleotide, particularly betacyanoethyl protecting groups from the internucleotide linkages, and nucleobase protecting groups. Preferred solvents are alkylamines, especially tri(alkyl)amines, such as tri(C_{1-4}-alkyl)amines, and most preferably triethylamine.

The processes according to the second aspect of the present invention can be employed in both small (ie <25mmol scale) and large scale oligonucleotide synthesis as described above in respect of the first aspect of the present invention.

The oligonucleotides can be assembled, and after washing, cleaved from the solid support, by the methods described above in respect of the first aspect of the present invention.

In both the first and second aspects of the present invention, the acetonitrile concentration is preferably reduced to less than 5%, often less than 3%, particularly less than about 2%, and especially less than about 1%, by weight of the oligonucleotide plus solid support.

An especially preferred embodiment of the present invention comprises assembling an oligonucleotide bound to a solid support in the presence of acetonitrile, air drying the supported oligonucleotide, contacting the dried supported oligonucleotide with

a trialkylamine, preferably triethylamine, for sufficient time to deprotect the oligonucleotide, and subsequently cleaving the oligonucleotide from the solid support.

In a related embodiment of the present invention, there is provided a process for the synthesis of phosphorothioate oligonucleotides which comprises:

a) assembling an oligonucleotide bound to a solid support in the presence of acetonitrile;

b) prior to cleaving the oligonucleotide from the solid support, washing the oligonucleotide bound to a solid support with a washing regime employing one or more solvent washes; and

c) cleaving the oligonucleotide from the solid support

characterised in that the final wash of the washing regime employs as solvent wash a solution comprising an alkylamine, preferably a tri(C_{1-4})alkylamine such as triethylamine, substantially free from acetonitrile. One or more solvent washes may be employed. It is preferred that acetonitrile is not employed in any of the solvent washes.

The synthesis of oligonucleotides using phosphoramidite chemistry wherein the oilgonucleotide is synthesised supported on a microporous support is believed to be novel. Accordingly, in a third aspect of the present invention, there is provided a process for the preparation of an oligonucleotide which comprises coupling a nucleoside or oligonucleotide phosphoramidite with a nucleoside or oligonucleotide comprising a free hydroxy group supported on a solid support to form an oligonucleotide phosphite triester, characterised in that the solid support is a microporous support.

Microporous supports are preferably poly(acrylamide) supports, such as those more commonly employed for the solid phase synthesis of peptides, may be employed if desired. Preferred poly(acrylamide) supports are amine-functionalised supports, especially those derived from supports prepared by copolymerisation of acryloyl-sarcosine methyl ester, N,N-dimethylacrylamide and bis-acryloylethylenediamine, such as the commercially available (Polymer Laboratories) support sold under the catalogue name PL-DMA. The procedure for preparation of the supports has been described by Atherton, E.; Sheppard, R. C.; in *Solid Phase Synthesis: A Practical Approach,* Publ., IRL Press at Oxford University Press (1984), the microporous supports of which are incorporated herein by reference. The functional group on amine-functionalised supports is a methyl ester and this is initially converted to a primary amine functionality by reaction with an alkyl diamine, such as ethylene diamine. The microporous supports are preferably employed in the form of polymeric beads.

The process according to the third aspect of the present invention is preferably carried out in the presence of a solvent which swells the microporous support. Examples of such solvents include haloalkanes, particularly dichloromethane; esters, particularly alkyl esters such as ethyl acetate and methyl or ethyl propionate; ethers such as

tetrahydrofuran; and preferably amides, such as dimethylformamide and N-methylpyrollidinone. The most preferred solvent is dimethylformamide.

The nucleoside or oligonucleotide phosphoramidite employed can comprise a 3'- or 5'-phosphoramidite group, most preferably a 3'-phosphoramidite group. Commonly, the phosphoramidite is a betacyanoethyloxy phosphoramidite. The nucleoside or oligonucleotide phosphoramidite commonly comprises a protected hydroxy group at whichever of the 3'- or 5'-positions is not a phosphoramidite. Preferably, at the 5'-position is a protected hydroxy group. Preferred protecting groups are pixyl and trityl, especially dimethoxytrityl, groups.

The nucleoside or oligonucleotide comprising a free hydroxy group employed can comprise a 3'- or 5'- hydroxy group, and is commonly bound to the solid support via whichever of the 3'- or 5' positions is not free hydroxy. Most preferably, the nucleoside or oligonucleotide comprising a free hydroxy group is bound to the solid support via the 3'-position, and comprises a free 5' hydroxy group.

The nucleoside or oligonucleotide comprising a free hydroxy group is commonly bound to the solid support via a cleavable linker.

The coupling of the nucleoside or oligonucleotide phosphoramidite with a nucleoside or oligonucleotide comprising a free hydroxy group takes place in the presence of a suitable activator. Examples of such activators are those known in the art for conventional phosphoramidite oligonucleotide synthesis, and include tetrazole, thioethyltetrazole, nitrophenyltetrazole and dicyanoimidazole. Commonly, the nucleoside or oligonucleotide phosphoramidite is employed as a solution in the solvent employed to swell the microporous support. Advantageously, the phosphoramidite solution is mixed with the swollen support comprising the free hydroxy group prior to addition of the activator as a solution in the solvent employed to swell the microporous support.

The oligonucleotide phosphite triester produced in the process of the third aspect of the present invention is commonly oxidised or sulphurised to form an oligonucleotide phosphate or phosphorothioate. Oxidising agents employed are those known in the art for conventional phosphoramidite oligonucleotide synthesis, and include iodine and t-butylhydroperoxide. Sulphurising agents employed are those known in the art for conventional phosphoramidite oligonucleotide synthesis, and include xanthane hydride, phenylacetyl disulphide and Beaucage reagent. The oxidising or sulphurising agents are commonly employed as a solution in the solvent employed to swell the microporous support.

A capping treatment, employing capping agents known in the art, for example a mixture of pyridine and acetic anhydride and a mixture of pyridine and N-methylimidazole, may be employed. Advantageously, the capping agents are employed in the presence of the solvent employed to swell the microporous support.

Pixyl or trityl protecting groups present in the oligonucleotide phosphate or phosphorothioate bound to the solid support, commonly at the 5'-position, can be removed by conventional detritylation techniques, for example by treatment with a solution of dichloroacetic acid. Preferably the dichloroacetic acid is employed as a solution in the solvent employed to swell the microporous support, for example dichloromethane or advantageously and amide, particularly dimethylformamide or N-methylpyrrolidinone. Removal of the pixyl or trityl protecting groups produces a free hydroxyl group which can then be employed for further coupling. Further couplings can be carried out in order to assemble the desired sequence. On completion of the assembly of the desired sequence, the product can be cleaved from the solid support using techniques appropriate to the linker employed.

The processes according to the present invention can be employed to synthesise phosphorothioated deoxyribonucleotides and ribonucleotides. The nucleotides may comprise bases, protecting groups and other modifications known in the nucleotide art. For example, bases which may be present include purines and pyrimidines, commonly A, G, T, C and U. Other bases which may be present include hypoxanthine, inosine and 2,6-diaminopurine. Protecting groups which may be present include base-protecting groups, such as benzyl, acetyl, phenoxyacetyl and isobutyryl groups, and hydroxy-protecting groups, such as pixyl and trityl, especially dimethoxytrityl, groups. Ribonucleotides may be modified at the 2'-position by an alkoxy or alkoxyalkyl substituent, such as a methoxy or methoxyethoxy substituent or may be protected at the 2'-position by a hydroxy protecting group such as tertiary butyldimethylsilyl, 1-(2-fluorophenyl)-4-methoxypiperidine-4-yl (Fpmp) or 1-(2-chlorophenyl)-4-methoxypiperidine-4-yl (Cpmp). Other modifications, including inverted nucleosides, abasic nucleosides and L-nucleosides may also be present. Deoxyribonucleotides may be modified at the 2'-position by a 2'-C-alkyl group. Chimeric nucleotides, including mixed deoxyribonucleotides and ribonucleotides, and/or mixed phosphate/phosphorothioate nucleotides can be prepared.

In many embodiments, the processes of the present invention are employed to prepare oligonucleotides having from 1 to 100, often from 5 to 75, preferably from 8 to 50 and particularly preferably from 10 to 30 internucleoside linkages. Commonly, the processes of the present invention are employed to prepare compounds wherein at least 50% of the internucleoside linkages are phosphorothioated, preferably at least 75%, and most preferably 90 to 100% phosphorothioated.

Examples of cleavable linkers that may be employed in the processes of the present invention include those well known in the art for the solid phase synthesis of oligonucleotides, such as urethane, oxalyl, succinyl, and amino-derived linkers. Succinyl linkers are preferred.

The invention will now be illustrated without limitation by the following examples.

Examples 1-3 and Comparison A

A sample of a fully phosphorothioated deoxyribonucleotide comprising 17 phosphorothioate groups was prepared using standard phosphoramidite chemistry. The product was produced trityl-on on a polystyrene support. After completion of the assembly and sulphurisaton, the supported nucleotide was washed with acetonitrile.

Three samples of the supported oligonucleotide were treated as follows. For Example 1, the supported oligonucleotide was air dried on a filter funnel. For Example 2, the sample was washed with triethylamine. For Example 3, the sample was washed with 2.5M aqueous sodium acetate solution. In each of Examples 2 and 3, the washing took place on a filter funnel under slightly reduced pressure, but operated so as to minimise evaporation of acetonitrile. The acetonitrile contents (% w/w) of the samples were measured by GC. The products of Examples 1 to 3 were cleaved using standard ammonolysis conditions using concentrated aqueous ammonia to obtain the oligonucleotide product. For Comparison A, a further sample of the supported oligonucleotide was cleaved under the same conditions, but without a drying or washing treatment. In each case, the weight percentage of P=O impurity in the samples was determined using Ion exchange chromatography. The results are given in Table 1 below.

Table 1

SAMPLE	Acetonitrile Content	% P=O
Comparison A	33%	9%
Example 1	<1%	5%
Example 2	1%	5%
Example 3	9%	5%

The results given in Table 1 show that the oligonucleotide produced by the processes of the present invention (Examples 1 to 3) gave significantly purer oligonucleotide products than the comparative process wherein the concentration of acetonitrile was not reduced prior to cleavage.

Example 4 - Synthesis of Oligonucleotide using a Microporous support

The following reaction was carried out under a nitrogen atmosphere.

To a 40 ml solid phase glass sinter/bubbler reactor of the type commonly employed in peptide synthesis, containing 1g of amine funtionalised poly(acrylamide) resin (loading 1mmol/g) obtained from Polymer Laboratories under the trade name PL-DMA, was added 3 equivalents of 5'-DMT-T-3'-succinate. Sufficient N-methylpyrrolidinone (NMP) was added to make the resin just mobile to nitrogen agitation, followed by 4 equivalents of

diisopropylcarbodiimide and 3 equivalents of diisopropylethylamine. The mixture was agitated with nitrogen until loading of the resin was complete as shown by the Kaiser test. The resin was washed with NMP (5 x bed volume) and dichloromethane (DCM, 5 x bed volume). 10 equivalents of pyrrole was added to the DCM wet resin followed by a 15% v/v solution of dichloroacetic acid (DCA) in DCM (2 x bed volume). The mixture was agitated with nitrogen for 1 hour and then washed with DCM (5 x bed volume) and NMP (5 x bed volume) to form a 5'-deprotected 3'-supported T.

3 equivalents of 5'-DMT-T-3'-(betacyanoethyloxydiisopropylamino)phosphoramidite was added to the supported T prepared above. Sufficient NMP was added to make the resin just mobile to nitrogen agitation, followed by 3.3 equivalents of S-ethyltetrazole. The mixture was agitated with nitrogen for 30 minutes, and then washed with NMP (10 x bed volume). Sulfurisation was achieved using Beaucage reagent (5 equivalents) for 60 minutes in the presence of sufficient NMP to make the resin just mobile to nitrogen agitation. The resin was washed with NMP (5 x bed volume) and DCM (5 x bed volume) to form a 5'-DMT protected supported dimer phosphorothioate. The detritylation, coupling and sulfuristaion cycles were repeated 2 further times to form a 5'-DMT supported tetramer phosphorothioate. This was detritylated using the using the conditions given above. Cleavage from the solid support, and removal of betacyanoethyl groups was achieved by treatment with concentrated aqueous ammonia solution for 48 hours at room temperature.

CLAIMS

1. A process for the large-scale synthesis of phosphorothioate oligonucleotides which comprises:

a) assembling an oligonucleotide bound to a solid support in the presence of acetonitrile; and

b) cleaving the oligonucleotide from the solid support;

characterised in that the concentration of acetonitrile is reduced to less than 10% by weight of the oligonucleotide plus solid support prior to the cleavage of the oligonucleotide from the solid support.

2. A process for the synthesis of phosphorothioate oligonucleotides which comprises:

a) assembling an oligonucleotide bound to a solid support in the presence of acetonitrile;

b) prior to cleaving the oligonucleotide from the solid support, washing the oligonucleotide bound to a solid support with a washing regime employing one or more solvent washes; and

c) cleaving the oligonucleotide from the solid support

characterised in that the final wash of the washing regime employs a solvent other than acetonitrile or dioxane.

3. A process according to claim 2, wherein the solvent is selected from the group consisting of aromatic hydrocarbons, aliphatic hydrocarbons, haloalkanes, esters, alcohols, amides, basic, nucleophilic solvents, polar ethers, sulphoxides, water, aqueous buffer solutions and mixtures of water and water miscible organic solvents.

4. A process according to claim 3, wherein the solvent is selected from the group consisting of toluene, cyclohexane, dichloromethane, ethyl acetate, methyl or ethyl propionate, C_{1-4} alkyl alcohols, dimethylformamide and N-methylpyrollidinone, pyridine, tri(C_{1-4}-alkyl)amines, tetrahydrofuran, dimethylsulphoxide and aqueous sodium acetate solution.

5. A process for the synthesis of phosphorothioate oligonucleotides which comprises:

a) assembling an oligonucleotide bound to a solid support in the presence of acetonitrile;

b) prior to cleaving the oligonucleotide from the solid support, washing the oligonucleotide bound to a solid support with a washing regime employing one or more solvent washes; and

c) cleaving the oligonucleotide from the solid support

characterised in that the final wash of the washing regime employs as solvent wash a solution comprising a trialkylamine.

6. A process according to either of claims 4 or 5, wherein the solvent is triethylamine.

7. A process for the synthesis of phosphorothioate oligonucleotides comprising assembling an oligonucleotide bound to a solid support in the presence of acetonitrile; air drying the supported oligonucleotide; contacting the dried supported oligonucleotide with a trialkylamine, preferably triethylamine, for sufficient time to deprotect the oligonucleotide, and subsequently cleaving the oligonucleotide from the solid support.

8. A process according to any preceding claim, wherein the acetonitrile concentration is reduced to less than 5%, and especially less than about 1%, by weight of the oligonucleotide plus solid support.

9. A process according to any preceding claim which is operated at or above a batch size of 10 mmol of oligonucleotide.

10. A process for the preparation of an oligonucleotide which comprises coupling a nucleoside or oligonucleotide phosphoramidite with a nucleoside or oligonucleotide comprising a free hydroxy group supported on a solid support to form an oligonucleotide phosphite triester, characterised in that the solid support is a microporous support.

11. A process according to any preceding claim, wherein the solid support is an amine-functionalised support derived from supports prepared by copolymerisation of acryloyl-sarcosine methyl ester, N,N-dimethylacrylamide and bis-acryloylethylenediamine.

12. A process according to claim 11, wherein the amine-funtionalised support comprises a primary amine functionality dervied from reaction of the methyl ester group with an alkyl diamine, preferably ethylene diamine.

13. A process according to any preceding claim, wherein the oligonucleotide is bound to the solid support via a cleavable linker selected from the group consisting of urethane, oxalyl, succinyl, and amino-derived linkers.

14. A process according to any preceding claim wherein the oligonucleotide is cleaved from the solid support by contact with a cleaving reagent.

15. A process according to claim 14, wherein the cleavage reagent comprises methylamine, aqueous methylamine solution, liquified ammonia, gaseous ammonia or concentrated aqueous ammonia solution.

16. A process according to any preceding claim which is employed to prepare oligonucleotides having from 1 to 100 internucleoside linkages.

17. A process according to any preceding claim which is employed to prepare compounds wherein at least 50% of the internucleoside linkages are phosphorothioated.

18. A process according to claim 17, wherein 90 to 100% of the internucleoside linkages are phosphorothioated.

(12) INTERNATIONAL PUBLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 June 2002 (13.06.2002)

PCT

(10) International Publication Number
WO 02/046205 A3

(51) International Patent Classification⁷: C07H 21/00

(21) International Application Number: PCT/GB01/05338

(22) International Filing Date: 3 December 2001 (03.12.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

0029610.3	5 December 2000 (05.12.2000)	GB
09/730,031	20 December 2000 (20.12.2000)	US

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(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

with international search report

before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

(88) Date of publication of the international search report:
15 August 2002

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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WO 02/046205 A3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/05338

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C07H21/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C07H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 40458 A (BECKMAN INSTRUMENTS INC) 30 October 1997 (1997-10-30) examples 19,22	1-9, 11-18
X	US 6 111 086 A (SCARINGE STEPHEN A) 29 August 2000 (2000-08-29) example II	1-9, 11-18
X	WO 92 09615 A (PHARMACIA LKB BIOTECH) 11 June 1992 (1992-06-11) example 5	1-9, 11-18
X	EP 0 323 152 A (APPLIED BIOSYSTEMS) 5 July 1989 (1989-07-05) example IV	1-9, 11-18

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2002	12.06.02

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bardill, W

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/05338

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 00 20431 A (ISIS PHARMACEUTICALS INC ;SCOZZARI ANTHONY (US)) 13 April 2000 (2000-04-13)	
X	CHEMICAL ABSTRACTS, vol. 91, no. 25, 1979 Columbus, Ohio, US; abstract no. 211802, ARSHADY, REZA; ATHERTON, ERIC; GAIT, MICHAEL J.; LEE, KAREN; SHEPPARD, R.C.: "Easily prepared polar support for solid phase peptide and oligonucleotide synthesis. Preparation of substance P and a nonadeoxyribonucleotide" XP002197392 abstract & J. CHEM. SOC. CHEM. COMMUN., 1979, pages 423-5,	10-18
E	WO 01 96358 A (SINHA NANDA D ;AVECIA BIOTECHNOLOGY INC (US)) 20 December 2001 (2001-12-20) page 13	10-18
X	EP 0 288 310 A (UNILEVER PLC ;UNILEVER NV (NL)) 26 October 1988 (1988-10-26) page 4, lines 19-26 page 11 -page 12	10-18
X	WO 94 01446 A (BECKMAN INSTRUMENTS INC) 20 January 1994 (1994-01-20) the whole document	10-18
X	US 4 753 985 A (ROSEVEAR ALAN ET AL) 28 June 1988 (1988-06-28) claim 3; example 6	10-18

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 01/05338

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-9, 11-18 (partially)

   Invention (1) as defined in claims 1-9 and 11-18 (partially) pertains to method of phosphorothioate oligonucleotide synthesis wherein the solvent acetonitrile is removed prior to the cleavage of the oligonucleotide from the support.

2. Claims: 10, 11-18 (partially)

   Invention (2) as defined in claims 10 and 11-18 (partially) refers to the use of a microporous support for oligonucleotide triester synthesis.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 01/05338

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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